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(56) Documents Cited
GB 2248361 A GB 2205706 A
Proc IEEE, Vol 73(4), Apr 1985, pp 523-549; H.G. Musmann et al; "Advances in picture coding."

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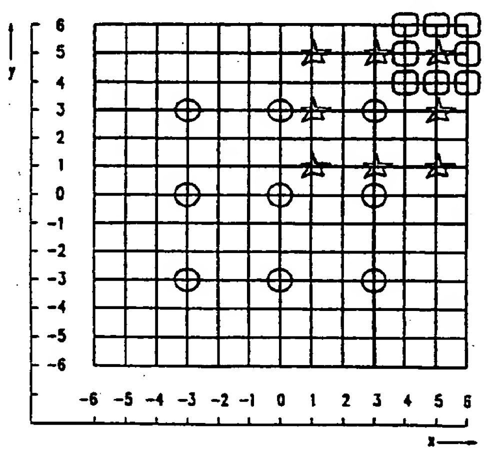
(54) **Method of determining motion vectors; weighting deviation function**

(57) In a method of determining motion vectors for a picture signal, in which each picture is divided into blocks and a motion vector is determined for each block in at least two steps, a number of motion vectors being assumed to be possible in each step and a deviation function for each pixel of the block being used for each of these assumed motion vectors, the most favorable vector being selected in dependence upon the value of its deviation function and being selected as one of the assumed vectors for the next step, if any, an optimal insensitivity to noise is obtained in that in the first step a first predetermined value is subtracted from the determined value of the deviation function of the vector having the smallest length, the thus reduced value being subsequently compared with the determined values of the deviation function of the other assumed motion vectors, and in that in a subsequent step a further predetermined value is subtracted from the value of the deviation function of that assumed motion vector which was determined as the most favorable motion vector in the previous step, and in that the thus reduced value of the deviation function of this vector is compared with the values of the deviation function of the other vectors of the same step for determining the most favorable vector. Each further predetermined valve is allow than the lasts.



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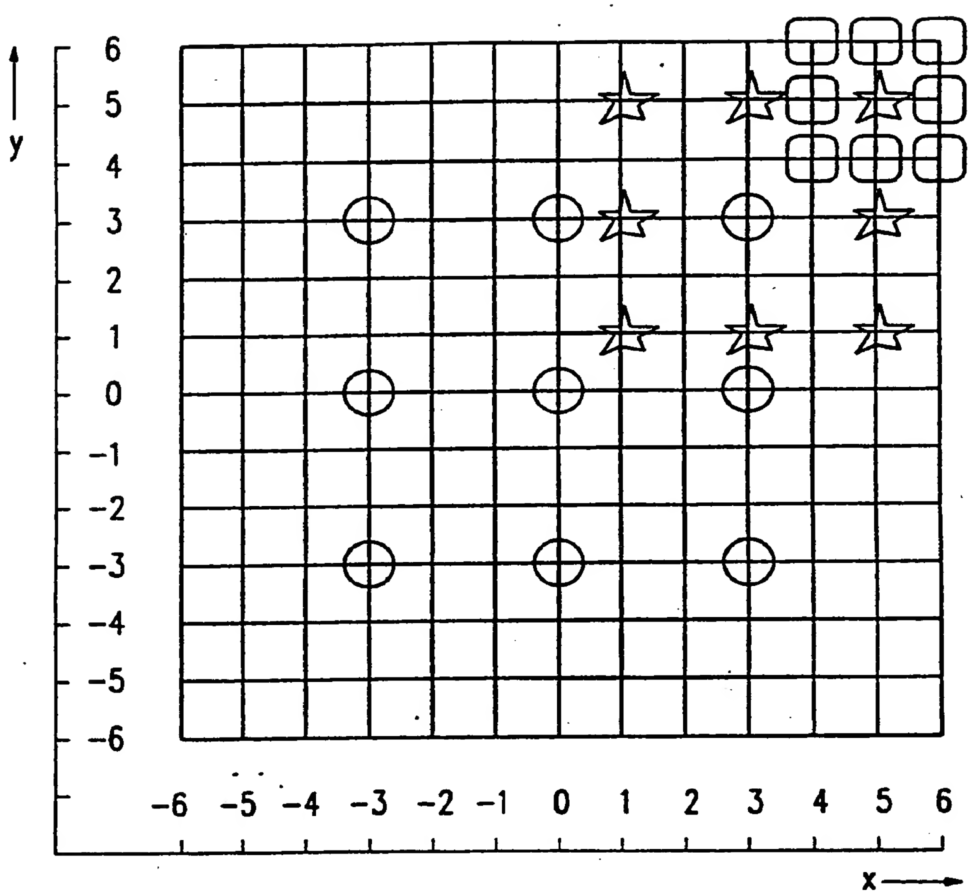

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Method of determining motion vectors.

The invention relates to a method of determining motion vectors for a picture signal divided into pictures or sub-pictures, in which each picture/sub-picture is divided into blocks and a motion vector is determined for each block in at least two steps, a number of motion vectors being assumed to be possible in each step and a deviation function for each pixel of the block being used for each of these assumed motion vectors, the most favorable vector being selected in dependence upon the value of its deviation function and being selected as one of the assumed vectors for the next step, if any.

Such a method is known, for example from "Proceedings of the IEEE, vol. 73, no. 4, April 1985, pp. 523 to 548". This method, which is generally referred to as 3-step block matching algorithm, provides a motion vector for a picture or sub-picture of a picture signal subdivided into a predetermined number of blocks, which motion vector is valid for all pixels of the associated block and indicates motion between two sub-pictures/pictures. In this case it is assumed that all pixels in one block are subjected to the same motion. The method operates in three steps in which in each block a predetermined number of motion vectors is assumed as a possible motion vector and in which, with reference to a deviation function for each individual pixel for each of these assumed motion vectors, it is checked which vector most likely represents the actual motion. In principle, in the deviation function the pixel in the current picture/sub-picture is compared with the corresponding pixel in the previous picture/field, which pixel is offset by the motion vector to be checked, for each pixel of the block for which a motion vector is to be checked. The larger the deviation between the two pixels, the larger the value of the deviation function for this pixel. Addition of all the pixels of the block then results in a value of the deviation function indicating for all pixels of the block in how far the value of the assumed motion vector correctly represents the actual motion. The larger the value of the deviation function, the poorer the assumed motion vector represents the actual motion.

In this way a search for the most favorable motion vector is performed in three steps. In the first step the motion vectors are chosen to be such that their values have relatively large mutual differences. The most favorable motion vector among these assumed motion vectors found in the first step of the method described hereinbefore is quasi-chosen as the starting point in the second step. In the second step further motion vectors around this motion vector are assumed, which are spread around the motion vector found as the most favorable in the first step. In the second step, a most favorable motion vector is found again in the manner described hereinbefore, which motion vector is chosen as the starting point for the third step. In the third step, further vectors are assumed around this vector found, which further vectors deviate to a relatively small extent from the motion vector found in the second step. In the third step, a most favorable vector is again determined in the manner described above, which vector represents the final value and which relatively precisely represents the motion in the block.

A problem of this method is that an error which occurs in the first step of determining the motion vector can only be partly corrected in the subsequent steps. In other words, if a motion vector is completely incorrect in the first step, it is no longer possible to correct this thoroughly in the subsequent steps. Such an error, particularly in determining the motion vector in the first step, particularly occurs due to noise but also due to periodically structured areas in which a similar structure is repeated over a given distance from the starting point (for example, a grating configuration). In such cases a false motion vector is often determined in the first step, which motion vector can only be finely corrected in the subsequent steps.

It is an object of the invention to further develop the method described in the opening paragraph in such a way that it is less sensitive to such errors.

According to the invention, this object is solved in that in the first step a predetermined value is subtracted from the determined value of the deviation function of the vector having the smallest length, the thus reduced value being subsequently compared with the determined values of the deviation function of the other assumed motion vectors, and in that in a subsequent step a predetermined value is subtracted from the value of the deviation function of that assumed motion vector which was determined as the most favorable motion vector in the previous step, and in that the thus

reduced value of the deviation function of this vector is compared with the values of the deviation function of the other vectors of the same step for determining the most favorable vector.

The invention is based on the recognition that the above-mentioned errors in the determination of motion vectors, particularly in the first step, are particularly caused by the fact that a motion is determined which actually does not exist. This particularly applies to the case in which the picture signal is noisy. By coincidental occurrence of noise-conditioned picture values, a motion may seemingly be present, but actually it does not exist. A corresponding situation applies in a similar manner to the further steps of the method. The periodical structure in this picture content also presents the risk that a motion is determined which is actually not present and which is simulated only by the periodical structure.

According to the invention, the value of the deviation function of the vector having the smallest length is therefore reduced by a predetermined value in the first step of the method. Generally, a family of assumed motion vectors is selected in the first step, *inter alia*, a vector of the value zero indicating no motion. In the manner described above the deviation function is determined for each one of the assumed vectors in the first step. The values of the deviation functions for each assumed motion vector are compared with each other and that motion vector whose value of the deviation function is smallest is assumed as the most favorable vector. According to the invention, before this comparison of the values of the deviation functions of the assumed motion vectors, the value of the deviation function of the vector having the smallest length, generally the zero length, is reduced by a predetermined value. Only thereafter is this reduced value of the deviation function compared with the values of the deviation functions of the other vectors. Due to this reduction of the value of the deviation function of the vector having the smallest length, it is achieved that this motion vector is chosen with priority. By subtracting a value from its deviation function, this motion vector is quasi-preferred so that in cases of doubt, in which the values of the deviation functions of the assumed motion vectors have similar values, this vector is selected.

Due to this procedure, it is achieved, particularly in the above-described cases of noise or repetitive picture contents, that in cases of doubt the motion vector

having the smallest length (generally zero length) is selected. Already in the first step, the method will thus be much less sensitive to the above-described errors.

In the further steps of the method again some motion vectors are assumed as possible vectors, for which the most favorable motion vector is selected in the manner described above. The motion vector determined as the most favorable in the first step is selected as the quasi-central vector. The other motion vectors, which are assumed as possible vectors, are chosen in such a way that they surround the motion vectors determined in the first step. After determination of the deviation functions for the assumed motion vectors in the second step, a predetermined value is again subtracted, in accordance with the invention, from that vector which was determined in the first step. In the second step this vector is then preferentially treated so that the vector determined in the first step is selected in the case of similar values of the other assumed vectors. A corresponding situation applies to a possible third step, in which in a similar manner the motion vector previously determined as the most favorable in the second step is preferred, in which vector a predetermined value is subtracted from its value of the deviation function before comparison with the values of the deviation functions of the other assumed motion vectors in the third step.

The advantages described hereinbefore are also obtained in the further steps. Overall, the method will be less sensitive to noise and periodical picture contents; simultaneously, the advantage is obtained that motion vectors which are generally relatively similar are determined for adjacent blocks, which is not the case in the state-of-the-art method, particularly in the case of noisy pictures.

The method is particularly suitable to advantage in an HD-MAC encoder which is to transmit motion vectors to an HD-MAC decoder enabling this decoder to correctly represent motions. On the other hand, these motion vectors are also required in the encoder itself.

In an embodiment of the method according to the invention, in which, in the first step, the assumed motion vectors are widely spread, in which, in a second step, they are closer around the vector determined in the first step and in which, in a third step, they are distributed even more closely around the vector determined in the second step, the value subtracted in the first step from the value of the deviation function of the vector having the smallest length is larger than the value subtracted in the second step

from the value of the deviation function of the displacement vector previously determined as the most favorable in the first step, while the value subtracted in the second step from the value of the deviation function of the displacement vector determined as the most favorable in the first step is larger than the value subtracted in the third step from the value of the deviation function of the displacement vector previously determined as the most favorable in the second step.

In the three-step method described hereinbefore, the assumed motion vectors are selected in the first step in such a way that they have a relatively wide spread. In the second step the assumed vectors are already closer together and in the third step they are closest. Due to this procedure it is achieved that the first step quasi-indicates a kind of coarse direction of the motion which is further refined in the subsequent steps so as to finally achieve the final value of the motion. For this procedure it is advantageous when the values, subtracted in accordance with the invention, from the deviation functions of the preferred assumed motion vectors are selected to be different in each step of the method. In the first step the value by which the value of the deviation function of the vector is reduced in the first step is to be chosen to be relatively large, while the subtracted values are then chosen to be smaller in steps 2 and 3. This results in an adaptation of the subtracted values and thus in a quasi-adaptation of the extent of preferring that vector from whose deviation function the value is subtracted to the extent of the spread of values of the assumed motion vectors in the respective step.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawing,

the sole Figure is a diagrammatic representation of a section of a block of a picture or sub-picture for which the method of determining motion vectors in three steps is used.

The drawing shows a scale ranging from -6 to +6 in the X direction as well as in the Y direction. The Figure shows nine crosses by which the assumed motion vectors are indicated for the first step. One of the motion vectors is arranged centrally and has the values X = 0 and Y = 0. This assumed motion vector thus represents the case where there is no motion. The other eight assumed motion vectors for the first step

are relatively widely spread and in the example shown in the Figure they deviate by the value of 3 from the motion vector X = 0, Y = 0 in the X and/or Y direction.

In the first step of the method a deviation function is formed for each of these nine assumed motion vectors, which function may be different but in any case is chosen in such a way that it indicates the deviation between a pixel of the current block and the corresponding pixel of the corresponding block of the previous picture or sub-picture displaced by the respective, assumed motion vector. The deviation function thus determined for each pixel of the block is added for an assumed motion vector so that this sum indicates in how far the assumed motion vector is generally correct for the pixels of the block.

According to the invention, this value of the sum of the deviation function of the vector having the smallest length is reduced by a predetermined value. In the exemplary case shown in the Figure the vector having the smallest length is the one having the value X = 0, Y = 0. The value of the deviation function for all pixels of this vector is now reduced by a predetermined value. Only thereafter is the value of the deviation function of this motion vector compared with the values of the deviation functions of the other eight assumed motion vectors. For the second step that motion vector is selected as the starting point whose value of the deviation function (or the reduced value of the deviation function) is smallest. If, for example, the values of the deviation functions for the nine motion vectors in the first step have similar values, the motion vector having the value X = 0, Y = 0 is selected because, according to the invention, its value has been reduced by a predetermined value so that the thus reduced value is smaller than the value of the deviation function of the other motion vectors and is thus chosen as the most favourable. In the representation shown in the Figure, it is assumed that this case does not exist, but that the assumed motion vector of the value X = 3, Y = 3 has a clearly lower deviation function which is also still lower than the reduced value of the deviation function of the motion vector having the value X = 0, Y = 0. In spite of the reduction of the value of the deviation function of the vector X = 0, Y = 0, the motion vector of the value X = 3, Y = 3 is selected.

In the second step of the method this motion vector determined in the first step is selected as one of the assumed motion vectors in the second step. The other motion vectors assumed in the second step surround the value of this motion vector.

They are represented by asterisks in the Figure. The deviation of the eight other assumed motion vectors from the central motion vector determined as the optimum vector in the first step is smaller than the deviation of the eight motion vectors in the first step which surround the central motion vector of the value X = 0, Y = 0.

In principle in the same manner as in the first step, the values of the deviation functions are determined and compared in the second step. Before this comparison a predetermined value is subtracted from the value of the deviation function of the vector X = 3, Y = 3 previously determined as the most optimum motion vector in the first step. This subtracted value is, however, smaller than the value by which the value of the deviation function of the motion vector X = 0, Y = 0 was reduced in the first step.

Also in the second step it holds that, in case of doubt and with similar values of all of the nine assumed motion vectors, that motion vector is selected which has the central value, *i.e.* that vector which was determined as the optimum motion vector in the first step.

The motion vector determined as the optimum vector in the second step (vector X = 5, Y = 5 in the Figure) is again selected as the central assumed motion vector in the third step, which vector is surrounded by the values of the other assumed motion vectors of the third step. These are represented by squares in the Figure.

In the third step, the procedure of the second step is repeated; in which the value of the deviation function of the vector determined as the optimum vector in the second step is reduced by a predetermined value. This value is again smaller than the value selected in the second step as a subtrahend of the motion vector previously determined in the first step.

Consequently, in the case of doubt the central motion vector is selected in each one of the three steps. This has the particular advantage that in the case of accidental values, which may particularly occur in noisy pictures, it is prevented that motion, which is actually not present, is indicated by the determined motion vector. The motion vector of the value X = 0, Y = 0 is "biased" in the first step and the motion vector which was determined in the previous step is "biased" in steps 2 and 3.

From reading the present disclosure, other variations will be apparent to persons skilled in the art. Such variations may involve other features which are already known in picture processing methods for television signals and apparatus for carrying out such methods and devices and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly, or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

Claims:

1. A method of determining motion vectors for a picture signal divided into pictures or sub-pictures, in which each picture/sub-picture is divided into blocks and a motion vector is determined for each block in at least two steps, a number of motion vectors being assumed to be possible in each step and a deviation function for each pixel of the block being used for each of these assumed motion vectors, the most favorable vector being selected in dependence upon the value of its deviation function and being selected as one of the assumed vectors for the next step, if any, characterized in that in the first step a predetermined value is subtracted from the determined value of the deviation function of the vector having the smallest length, the thus reduced value being subsequently compared with the determined values of the deviation function of the other assumed motion vectors, and in that in a subsequent step a predetermined value is subtracted from the value of the deviation function of that assumed motion vector which was determined as the most favorable motion vector in the previous step, and in that the thus reduced value of the deviation function of this vector is compared with the values of the deviation function of the other vectors of the same step for determining the most favorable vector.

2. A method as claimed in Claim 1, in which, in the first step, the assumed motion vectors are widely spread in which, in a second step, they are closer around the vector determined in the first step and in which, in a third step, they are distributed even more closely around the vector determined in the second step, characterized in that the value subtracted in the first step from the value of the deviation function of the vector having the smallest length is larger than the value subtracted in the second step from the value of the deviation function of the displacement vector previously determined as the most favourable in the first step, and in that the value subtracted in the second step from the value of the deviation function of the displacement vector determined as the most favorable in the first step is larger than the value subtracted in the third step from the value of the deviation function of the displacement vector previously determined as the most favorable in the second step.

3. A method of determining motion vectors substantially as described herein with reference to the accompanying drawing.

4. Any novel feature or novel combination of features disclosed herein either explicitly or implicitly whether or not it relates to the same invention as that claimed in any preceding claim.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9316105.7

Relevant Technical fields	Search Examiner
(i) UK Cl (Edition L) HGF (FGM) (ii) Int Cl (Edition 5) H04N (5/14); G06F (15/70)	M K REES
Databases (see over) (i) UK Patent Office (ii) ONLINE DATABASE: WPI	**Date of Search** 6 OCTOBER 1993

Documents considered relevant following a search in respect of claims 1-3

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2248361 A (SONY) See page 19 line 14 - page 21 line 22; Figure 22	1
X	GB 2205706 A (SONY) See page 8 line 6 - page 9 line 6; page 16 lines 5-17	1, 2
Y	Proc IERR, 73(4), April 1985, pages 523-548; H G Mosmann et al; "Advances in picture coding" See especially pages 523-530	1, 2

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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